Electron-phonon relaxation in hot-electron detectors below 1 K

B.S. KARASIK[a], A.V. SERGEEV [b],
and M.E. GERSHENSON[c]

[a] Jet Propulsion Laboratory, California Institute of Technology
[b] Wayne State University
[c] Rutgers University

Recently proposed submillimeter hot-electron direct detectors based on normal metals and superconductors rely on the thermal coupling between electrons and phonons. The sensitivity of the detectors can be greatly enhanced if the coupling is made very weak at subkelvin temperatures. According to the theory taking into account an interference between electron-phonon and electron-impurity scattering [M.Yu. Reizer and A.V. Sergeev, *Sov. Phys.- JETP* **63**, 616 (1986); J. Rammer and A. Schmid, *Phys. Rev.* B **34**, 1352 (1987)], use of impure films should be the way to achieve this goal. So far, the experimental situation has been somewhat confusing about this issue. A number of experimental studies have shown a cubic temperature dependence of the electron-phonon relaxation rate below 1 K. A seemingly natural explanation is that this dependence is caused by direct interaction between electrons and phonons. However, an accurate consideration shows that in most of these studies the pure limit was not reached, and the dimensionless parameter ql (q is the phonon wavevector, l is the elastic electron mean free path) was of the order of 1. In this case, the electron scattering from vibrating impurities/boundaries dominates. The electron-phonon scattering rate varies from $T^4 l$ for $ql << 1$ to T^2/l for $1 << ql < 2(u_l / u_t)^3 \sim 20$-$40$ (u_l and u_t are the longitudinal and transversal sound velocities). In a wide temperature range around $T \sim u_t / l$ the relaxation rate should have a T^3 temperature dependence along with a weak l-dependence. We will show that a majority of known experimental data below 1 K falls in this range of parameters. Our recent experimental data for W and Ti films are in good agreement with the discussed interference mechanism. The measured electron-phonon relaxation time followed the T^{-4} dependence and was a record-long (25 ms) at 40 mK.

Corresponding author:	Dr. Boris S. Karasik
Full mailing address:	Jet Propulsion Laboratory, 4800 Oak Grove Drive, M/S 168-314, Pasadena, CA 91109, USA
Tel.:	+1 (818) 393-4438
Fax:	+1 (818) 393-4683
E-mail:	Boris.S.Karasik@jpl.nasa.gov
Presentation preference:	Oral